Energy Storage in the New York Electricity Markets

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Introduction

At the heart of the electric system is the need to balance supply and demand on a moment-to-moment basis. Energy commodities such as natural gas, oil, and coal can be readily stored in massive quantities. In contrast, the storage of electricity has been relatively expensive and complex. Electric system operators often need to rely on reserves of conventional generation to meet changes in demand (i.e. consumption). However, emerging technologies designed to store electricity can provide significant energy, economic and environmental benefits.

The New York Independent System Operator (NYISO) is committed to integrating resources that promote the reliability and market efficiency of New York State's electric system. New and emerging energy storage technologies, which include flywheels, advanced batteries, compressed air energy storage (CAES) and plug-in electric vehicles (PEVs) represent a new class of resource that has the potential to create a more robust power system and lower costs to consumers. Increased amounts and types of electric energy storage have the potential to work with smart grid technology to support the integration of large amounts of renewable energy into the electric grid. The New York Public Service Commission (NYPSC)[1] and the Federal Energy Regulatory Commission (FERC)[2] have acknowledged the important role that energy storage plays in the implementation of smart grid technologies.

In February 2007, the FERC sought to reduce barriers to the inclusion of alternative power suppliers in electricity markets.[3] The NYISO, consistent with the FERC's guidance, is working with alternative suppliers to facilitate their integration into the New York electricity market. In 2009, the NYISO, working with stakeholders via its shared governance process, developed new market rules and related market software that specifically supported the integration of a class of resources known as Limited Energy Storage Resources or "LESRs."[4]

Like all energy storage resources, LESRs act as a consumer of electricity (an electrical load) when they store energy delivered by the electric grid. When they later release that stored energy, they act as a supplier of electricity. The main benefit of LESRs is the speed of their response to dispatch, not the duration of that response. The "limited" aspect of LESRs reflects the limited amount of time for which they can sustain energy output. LESRs ability to respond rapidly to control signals and continually recharge makes them a valuable resource for Regulation Service. Regulation Service is a critical ancillary service used by grid operators to keep the electric grid in constant balance.

[1] NYPSC Case 09-E-0310. In The Matter of the American Recovery and Reinvestment Act of 2009 – Utility Filings for New York Economic Stimulus. Appendix A. Pg. 8. July 24, 2009.
[2] FERC Docket No. PL09-4-000. Smart Grid Policy. Pg. 48. July 16, 2009.
[3] FERC Order No. 890. February 16, 2007. http://www.ferc.gov/whats-new/comm-meet/2007/021507/E-1.pdf.
[4] FERC Order Accepting Tariff Revision. Docket Nos. ER09-836-000 and ER09-836-001. May 15, 2009.

Integration of all types of energy storage technologies into the modern electric grid is becoming a priority. Storage resources can complement intermittent renewable resources such as wind and solar power by storing excess power for delivery when it is most needed. Some storage resources, particularly LESRs, are well suited to providing Regulation Service that has traditionally been supplied by conventional hydroelectric and thermal units. The use of storage for services that require fast response helps to improve system efficiency while reducing the need to burn fossil fuels to provide this service.

Energy storage technology is currently advancing with federally sponsored research, state-level initiatives and regional pilot programs dedicated to developing a wide range of storage options. Plug-in Electric Vehicles (PEVs), for example, may one day act as a large scale energy storage service provider for both the home and the electric grid.

This paper reviews existing energy storage technologies, discusses the NYISO's efforts to integrate new energy technologies such as limited energy storage devices, and looks at future initiatives and technologies.

Electric System Dynamics

Demand for electricity is dynamic, changing with time-of-day, seasonal climate, and consumer behavior. There is greater demand for electricity during the hot summer months than the moderate times of spring and fall. Power consumption is higher during the daytime hours and lower late at night. Demand patterns change from one hour to the next, and also experience moment to moment fluctuations. Electric system operators manage these changes with a variety of tools.

Hour by hour changes in demand are normally managed by increasing or decreasing the set of resources that need to be operating to meet demand in that hour (unit commitment). Minute by minute fluctuations in demand are managed by directing the more flexible resources to increase or decrease their output. Second by second fluctuations in the balance between supply and demand are managed through the use of the ancillary service known as Regulation. Every six seconds, system operations directs the output of Regulation Service suppliers up or down to keep the system in balance.

Much of the generation fleet in New York is powered by fossil fuels, nuclear energy and hydroelectric facilities. Coal and oil can be stored until needed. Natural gas can be utilized on demand to the extent that delivery has been secured or gas pipeline capacity is otherwise available. The operating characteristics of some of these generating resources, however, require that they run continuously, even overnight when demand is low. Some energy storage facilities are designed to store the electric energy generated overnight when demand is low and release it during the peak hours of the day when demand is greater.

Many of the newer storage technologies are designed not to store power for use in meeting peak demand during the day, but to respond to second by second fluctuations in demand and, thereby, improve system reliability and power quality.

The NYISO purchases Regulation Service on behalf of all users of the power system. Regulation Service (sometimes referred to as automated generation control or AGC) is optimally delivered by resources that can respond to six second dispatch signals with a high level of speed and precision. Regulation Service ensures system stability and reliability. The NYISO continuously monitors system frequency and control area interchange, sending signals to Regulation Service providers every six seconds, to make adjustments as necessary to balance electricity demand and supply.

Potential Benefits of Energy Storage

Energy storage resources have the potential to offer a number of valuable benefits to the New York electric grid including improving the economic efficiency of the power system and enhanced integration of renewable technologies.

Economic Benefits

Figure 1 below shows the difference between the average peak and off-peak prices in the day-ahead energy market in New York.[5] These differences generally are greatest between hours in the middle of the night which represent the lows of energy demand and price, and the hours in the middle of the day which represent the highs of energy demand and price. The spread between the peak and off-peak prices represents an opportunity for resources that can economically store energy for hours or days to purchase power from the grid overnight and then sell that power back into the grid during the peak demand hours of the day. The availability of the stored energy during peak hours could reduce the necessity for dispatching expensive peaking generators which are typically powered by fossil fuels.

Other storage resources can provide economic value by providing fast-response service. The Regulation Service product is the highest priced ancillary service[6] in the New York wholesale electricity markets. The cost to provide Regulation Service to consumers has increased in recent years.[7] Market-based Regulation payments totaled $100 million in 2008. Higher Regulation service price levels and the prospect of increasing demand for Regulation Service have attracted the attention of developers whose technologies are

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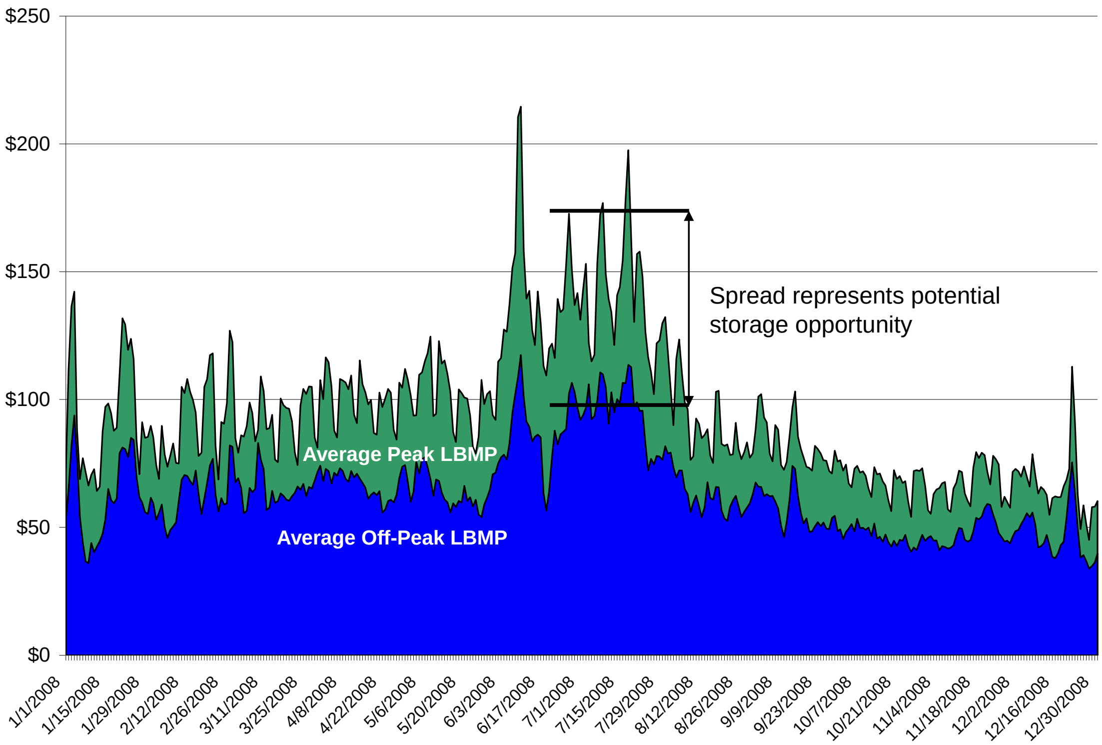
[5] Peak hours are shown here as hours beginning 6 thru 21 for all seven days of the week.

[6] Ancillary services are necessary to support the transmission of energy from generators to consumers, while maintaining reliable operation of the power system in accordance with good utility practice and reliability rules. Ancillary Services include Scheduling, System Control and Dispatch Service; Reactive Supply and Voltage Support Service (or "Voltage Support Service"); regulation and Frequency Response Service (or "Regulation Service"); Energy Imbalance Service; Operating Reserve Service (including Spinning Reserve, 10-Minute Non-Synchronized Reserves and 30-Minute Reserves); and Black Start Capability.

[7] Regulation settlement data for the period 2005 thru 2008 from NYISO Decision Support System.

well suited to serve the Regulation market. The NYISO's market-based dispatch is providing the economic signal for investment in new storage technologies.

Figure 1: Daily Day-Ahead Peak vs. Off-Peak Price Differentials (2008)



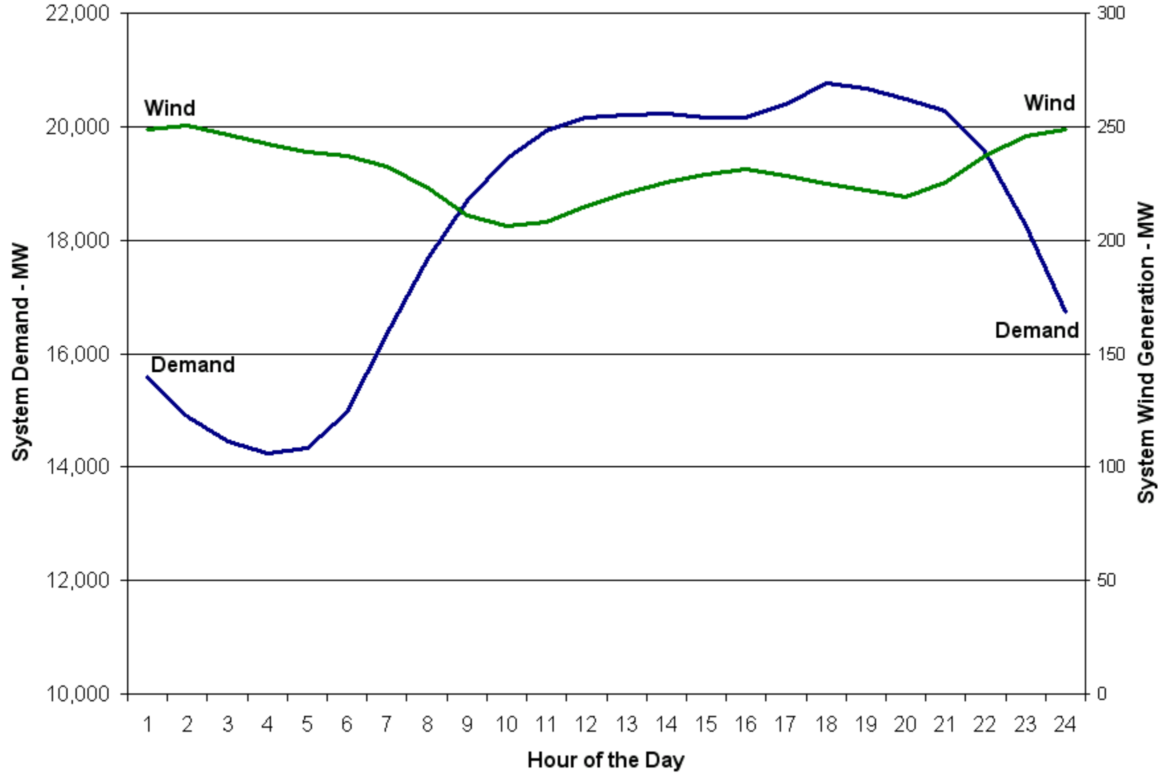
Intermittent Resource Integration Benefits

Renewable resources represent an increasing portion of the electric generation in New York State. However, the electricity available from renewable resources such as wind and solar energy is intermittent due to their dependency on weather. Technologies that provide the ability to store intermittently generated power can expand the use of such resources by smoothing out the variations in its hour-by-hour, minute-by-minute and second-by-second availability. This can be particularly important for those renewable generation technologies such as wind that peak at night when demand is low.

Energy storage can increase the usefulness of wind power in meeting New York's demand for electricity by absorbing excess wind generated overnight and supplying that power to the grid during peak daytime hours. It can also help grid operators deal with the second-by-second variability of wind and solar by providing additional Regulation Service.

As Figure 2 below shows, wind generation in New York typically peaks at a time when demand for electric power is at its lowest.

Figure 2: Average Hourly Wind Output vs. Demand (2008)



Wind power, in terms of both capacity and generation, has surged in New York State in recent years. Since the beginning of 2007, more than 1,200 megawatts of wind capacity has been added to the grid. The continued growth of wind as a generation resource is expected for the foreseeable future due to a variety of factors including open access to the grid, price signals provided by NYISO's wholesale electricity markets, the State's Renewable Portfolio Standard (RPS), New York's participation in the Regional Greenhouse Gas Initiative (RGGI), and the potential for Federal programs controlling carbon emissions.

The NYISO Interconnection Queue[8] includes almost 7,000 megawatts of wind power projects, which represent about 40% of the generating capacity in the queue. While there are no guarantees that all of the proposed projects will be built, the significant number of potential projects is an indicator of the positive prospects for further wind development in New York State.

Energy storage resources, combined with the NYISO's pioneering wind dispatch system,[9] can help New York take full advantage of its wind power resources. As mentioned, wind plants operate at higher levels when the wind is strongest, often during

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[8] NYISO Interconnection Queue. February 16, 2010. http://www.nyiso.com/public/webdocs/services/planning/nyiso_interconnection_queue/nyiso_interconnection_queue.xls.

[9] FERC Docket No. ER09-802-000. May 11, 2009. http://www.nyiso.com/public/webdocs/documents/regulatory/orders/2009/05/FERC_Order_Wind_Integration_5_11_09.pdf.

overnight, off-peak hours. To the extent that wind would need to be curtailed because of low demand in these off peak hours, additional energy storage could absorb that additional wind power and release it in higher demand periods.

The combination of low demand and high levels of output from wind and baseload facilities may result in transmission constraints that limit the ability of wind resources to deliver their output to the grid in certain hours. Suitably located storage facilities can absorb wind power that would otherwise go unused and deliver the power when needed. The availability of the stored wind power during peak hours could offer lower-priced electricity and emission-free renewable power. These conclusions are echoed in a recent energy storage study conducted by Sandia National Laboratories. The study indicates that excess wind power that is absorbed by energy storage resources at night could help reduce the level of harmful emissions and costs by reducing the need to dispatch fossil peaking generators during the day.[10]

Energy Storage Technologies

Electric energy storage technologies come in many forms – some decades old, and others emerging due to advancements in materials, electronics, chemistry, and information technology. The technologies described in this section represent some of the technologies that are currently available or under development in New York. It is not an exhaustive list of all possible energy storage technologies.

Hydropower Based Storage

Energy can be stored by conventional hydropower and pumped storage hydropower facilities. Some conventional hydropower facilities have reservoirs where retained water (also known as “pondage”) can be held and later released when demand and prices are higher.

A pumped storage resource is a hydropower generating facility that stores water as potential energy during off-peak hours for later use when demand is higher. These facilities consist of a hydro-electric power plant served by two reservoirs at different elevations. Water is pumped by the power station from the lower reservoir to an upper reservoir where the water is stored until it is needed to generate power. When the time comes to generate power the water is allowed to flow downhill. The downhill flow of water spins turbines which generate electricity.

Pumped storage facilities actually consume more electricity than they generate on a net basis, so unlike conventional hydropower there is a short-run cost to storage. The value (in terms of both economics and reliability) of pumped storage resources is derived from their ability to deliver power when it is needed most. When the cost of pumping is less than the price differential between on and off-peak pumped storage facilities can

[10] Eyer, Jim, & Corey, Garth (2010). Sandia National Laboratories. Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide. Section 3.6.1.2, Energy Time-shift from Wind Generation.

effectively arbitrage these prices by purchasing power off-peak and selling the power at peak.

The vast majority of power generated from pumped storage resources in New York comes from the Blenheim-Gilboa facility. Owned by the New York Power Authority (NYPA), Blenheim-Gilboa is located in the Catskill Mountains west of Albany, NY. The facility is the fifth largest in the U.S. on a capacity basis and has four generating units that have a combined nameplate capacity of 1,116 megawatts.[11] New York State's other major pumped storage facility is the Lewiston Pump-Generating Plant, also owned and operated by NYPA. With a nameplate capacity of 240 megawatts, the Lewiston plant is part of the Niagara Power Project complex near Niagara Falls, which includes a reservoir that allows the conventional portion of the power project to store some energy as well.

Within New York State, pumped storage accounted for 4% of capacity and 1.1% of all generation output in 2008.[12] Across the U.S., electricity from pumped storage facilities represented about 2% of total capacity and 0.5% of all electric power generation in 2008.[13] The pumped storage portfolio in New York is not expected to expand significantly during the near term due to a lack of sites where pumped storage facilities can be economically constructed.

Compressed Air Energy Storage

Compressed air energy storage (CAES) is a storage technology that has much in common with pumped storage because it has the ability to convert its stored air capacity to real power output for several hours at a time during peak hours. CAES systems use excess power from the grid during off-peak hours to compress and store air in underground caverns. During high demand periods of the day, the compressed air can be released into the combustion cycle of a conventional natural gas turbine generator to increase its efficiency by 30% or more. In addition to increased efficiency, CAES plants have quick ramping capability which means that they can provide fast response when grid operators need a provider of ancillary services.

CAES facilities have longer charge and discharge cycles than LESRs, so they operate in the market in a manner similar to pumped storage, compressing air in the off-peak hours and releasing energy during peak hours. Unlike LESRs, CAES plants can also supply Energy and Operating Reserve service to the grid.

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[11] The Blenheim-Gilboa project is undergoing a life extension and modernization program. When completed in 2010, the project's nameplate capacity is expected to total 1,160 megawatts.

[12] NYISO Load and Capacity Data Report. August 28, 2009. http://www.nyiso.com/public/webdocs/services/planning/planning_data_reference_documents/2009_LoadCapacityData_PUBLIC_Final.pdf.

[13] Electric Power Annual (2008). Energy Information Administration. March 16, 2010. http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html.

In order to be considered viable CAES facilities need at least three basic elements. First, these facilities need a confined space (such as a salt cavern) that can securely store a sufficient volume of compressed air. Second, the location must have access to natural gas transmission in order to power the turbine. Finally, the site must have access to electric transmission so that the power generated can be delivered to the grid.

Some locations within New York State may have access to the elements required to site a CAES facility. According to the Energy Information Administration (EIA) Western New York has approximately 228 million cubic feet of underground storage capacity across 24 depleted natural gas fields and salt caverns.[14] Western New York locations may also have access to an existing natural gas pipelines and high-voltage transmission lines.

In February 2008, developers began a statewide engineering study of the feasibility of a variety of compressed air storage technologies and related infrastructure interconnection issues for a 300-megawatt CAES facility using salt caverns in New York.[15] In December 2009, New York State Electric & Gas (NYSEG) received a $29.6 million award from the Department of Energy in support of a CAES demonstration project in Watkins Glen, NY.[16]

Limited Energy Storage Resources

Like pumped storage and CAES resources, LESRs act as a demand (a consumer of electricity) when they store energy delivered by the electric grid. When they later release that stored energy, they act as a supplier of electricity. A key difference is that while energy production from a pumped storage facility is typically measured in hours, the duration of energy production from a LESR is measured in minutes.

Different operating characteristics create distinct economic opportunities for LESRs compared to other forms of energy storage. Pumped storage resources can arbitrage price by purchasing lower priced off-peak power and selling power during peak hours of the day. LESRs are not designed for daily price arbitrage since they constantly charge and discharge. Therefore, the economic opportunity for LESRs is not in shifting power from off-peak to on-peak, but from their rapid response rate. The rapid response rate of LESRs makes this technology a very attractive Regulation resource because the Regulation product requires a fast response to NYISO dispatch signals.[17]

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[14] Underground Natural Gas Storage Capacity: Energy Information Administration. March 2, 2010. http://tonto.eia.doe.gov/dnav/ng/ng_stor_cap_dcu_SNY_a.htm.

[15] New York State Energy Research and Development Authority (2008). NYSERDA Awards $6 million in Power Delivery R&D Projects. http://www.nyserda.org/Press_Releases/2008/PressRelease20080402.asp.

[16] AllBusiness. NYSEG receives funds to study wind-energy storage in salt caverns. December 18, 2009. http://www.allbusiness.com/energy-utilities/utilities-industry-electric-power-power/13738809-1.html.

[17] NYISO. LESR Market Integration Update. April 27, 2009. http://www.nyiso.com/public/webdocs/committees/bic_prlwg/meeting_materials/2009-04-27/LESR_PRLWG_Presentation.pdf.

Current LESR technologies that have been proposed for integration in the NYISO markets include flywheels and batteries. A flywheel energy storage system is a rotating mechanical device (i.e., a rotating disk) that uses electricity from the power grid to store and then discharge kinetic energy. Battery storage systems convert electricity into chemical energy for later release.

Beacon Power, Inc. and AES Energy Storage, LLC, are two companies planning to develop grid-scale LESR facilities in New York based on flywheel and battery technology.

Beacon Power is constructing a 20-megawatt flywheel energy storage facility designed to provide Regulation Service to the electric grid. Beacon's system utilizes 1 megawatt flywheel modules consisting of 10 individual 25kWh/100kW flywheels integrated into a plant that can provide up to 20 megawatts of Regulation Service. Beacon received a conditional commitment for a $43 million loan guarantee from the U.S. Department of Energy and broke ground in Stephentown, New York on November 19, 2009.[18] In addition, Beacon is reportedly planning to build other facilities in New York.[19]

AES Energy Storage has proposed three 20-megawatt battery storage facilities in the upstate New York counties of Broome, Onondaga and Niagara. AES has previously developed a 2 x 1 megawatt grid-scale energy storage system constructed with battery cells manufactured by Altair Nanotechnologies. The system has the capability to deliver one megawatt of power to the grid for 15 minutes.

There is significant growth in small-scale storage technologies to help meet power quality needs, support integration of renewable resources and to electrify the transportation system. In addition to batteries and flywheels, other developing technologies that could act as LESRs in the New York market include flow batteries, fuel cells, and supercapacitors. The NYISO expects that more companies will propose additional storage technologies for development in New York.

New Market Design to Accommodate Storage

The original NYISO wholesale market was designed when traditional resources, such as pumped storage and fossil fuel generation units, submitted bids for both energy and ancillary services including regulation. In the past few years, new technologies have become available that make energy storage more efficient and economical. This class of devices has an energy capacity limitation that precludes them from taking part in the energy market and thus would not fit into NYISO market model without market design modifications. Consistent with its mission to evolve the markets, the NYISO in

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[18] Beacon Power. U.S. Department of Energy Offers $43 Million Loan Guarantee to Beacon Power for Flywheel Energy Storage Project. July 2, 2009. http://phx.corporate-ir.net/phoenix.zhtml?c=123367&p=irol-newsArticle&ID=1304253.

[19] The Daily Gazette (Schenectady, NY). $45 million Glenville plant to store power for grid. September 26, 2009. http://www.dailygazette.com/news/2009/sep/26/925_plantglen/.

collaboration with stakeholders participating in its shared governance process, crafted a market enhancement that will allow Limited Energy Storage Resources to participate in the NYISO Regulation markets.

To provide them access to the market, a new type of Regulation Service provider was defined: a Limited Energy Storage Resource ("LESR"). A LESR is characterized by its ability to provide continuous six-second changes in output coupled with its inability to sustain continuous operation at maximum energy withdrawal or maximum energy injection for an hour. LESRs are limited to providing Regulation Service in the NYISO markets.

LESRs are compensated for the value of their Regulation Service in the same manner as traditional suppliers – that is by being paid the market clearing price for Regulation Service. In other respects, however, their service is compensated differently. For instance, LESRs are not yet subject to "performance adjustments." The NYISO measures performance using its Performance Tracking System (PTS) and adjusts the energy compensation of traditional Regulation providers based on these results. LESR responsiveness is much more rapid than any other Regulation Service suppliers' and the NYISO has not yet tested the ability of its existing metering technology to capture an accurate measure of that responsiveness for purposes of performance testing. Until more is known about the ability of the NYISO to measure LESR responsiveness accurately, the NYISO will assume "perfect performance."

Another necessary change to market design was in the bids used for scheduling these resources. Whereas Regulation Suppliers are scheduled using both their Regulation Service availability bids and their Energy bids, LESRs are scheduled only on the basis of their Regulation availability bids. In addition, LESRs are not compensated for the energy provided to the system while providing Regulation Service. Rather, the energy they provide is netted against the energy they use over each hour with the product of that calculation multiplied by the average energy LBMP over the hour to produce an hourly energy charge or payment.[20]

Following stakeholder discussions on the issue, the NYISO filed tariff revisions in 2009 to, "…allow the NYISO to accommodate the unique characteristics of energy storage devices, consistent with all applicable reliability criteria, in a manner that treats them comparably to other Regulation Service providers."[21] The revisions include the following key changes to the market software and rules:

1. Market software was modified to allow LESRs to be economically scheduled on the basis of their Regulation availability bid only.

[20] Ibid, Section 4.7.4.
[21] NYISO. Docket No. ER09-836-000, Proposed Tariff Revisions to Integrate Energy Storage Devices into the NYISO Administered Regulation Service Market. May 15, 2009. http://www.ferc.gov/EventCalendar/Files/20090515142559-ER09-836-000.pdf.

2. Real Time Dispatch (RTD) was modified to evaluate LESR energy storage, the capability of the LESR to sustain withdrawals and injections over the five-minute scheduling horizon. If LESR storage is insufficient to provide regulation, another resource will be dispatched by RTD. By monitoring LESR energy storage, RTD can calculate the upper and lower regulation capability of the device and schedule the LESRs regulation capacity accordingly. In the event that the LESR capacity is below the scheduled day-ahead capacity for that five-minute interval due to the LESRs energy storage limitation the LESR will be required to purchase replacement Regulation Service comparable to all Regulation Service providers.[22]

3. Automated Generation Control (AGC) software was modified to dispatch LESRs first (if their storage capability allows) to take advantage of their extremely fast response capabilities and to avoid energy deployments on slower moving generators. This modification increases electric system efficiency, reduces cost and improves overall control performance. AGC software was also modified to recognize when the LESR was approaching a fully charged or fully discharged state. AGC will ramp or reduce the energy schedule on the device as the device is reaching its maximum or minimum energy storage position. This is done so that the energy schedule will be reduced to zero to coincide with the point in time when the device reaches a fully charged or discharged state. This process prevents the instantaneous transition of the device from one that is addressing a regulation error to one that is causing regulation error.

By removing the requirement to offer energy, and by creating an opportunity to sell regulation as a stand-alone product, the NYISO has been able to create a market for a new class of resources.

Emerging Energy Storage Developments

A number of emerging developments could enhance the role of energy storage in New York's wholesale electricity markets.

New York Battery and Energy Storage Technology Consortium

In May 2009, New York Governor David Paterson announced the creation of the New York Battery and Energy Storage Technology Consortium (NY BEST). The ultimate goal of NY BEST is to, "…position New York as the global leader in energy storage technology."[23] To support NY BEST the state has set aside $25 million to finance the development of energy storage technologies, including battery testing, in New York. The NY BEST program will be administered by the New York State Energy Research and

[22] NYISO. Ancillary Services Manual – Version 3.15, Section 4.2. October 21, 2009.

[23] New York State. Governor Paterson Announces Creation of the New York Battery and Energy Storage Technology Consortium (NY BEST). May 5, 2009. http://www.state.ny.us/governor/press/press_0505094.html.

Development Authority (NYSERDA), which has created a program plan[24] that provides details on how NY BEST will achieve its goals.

Federal Research and Development

The U.S. Department of Energy (DOE) conducts ongoing research and development (R&D) in the areas of advanced batteries and energy storage technologies. The fiscal year 2008 progress report issued by the DOE[25] provides some insight into the current state of R&D for vehicles taking place at the federal level. DOE also sponsors grid-level energy storage projects via Sandia National Laboratory.[26]

The Energy Storage Systems (ESS) program at Sandia National Laboratory focuses on the development of energy storage technologies and systems in order to increase the reliability and performance of electric generation and transmission systems in utility and non-utility applications. Sandia is conducting an ongoing collaboration with the California Energy Commission to demonstrate the viability and cost effectiveness of integrating energy storage into the electric grid. Sandia is also partnering with NYSERDA on energy storage demonstration projects in New York. The Joint Energy Storage Initiative is aimed at demonstrating the viability of energy storage as an option to increase grid reliability in New York.[27] Battery and flywheel energy storage projects are included in the initiative.

Vehicle-to-Grid Applications

A significant amount of research is occurring in the area of advanced batteries for plug-in electric vehicles (PEVs). While the goal of developing commercially viable PEVs is primarily a measure to reduce U.S. dependence on foreign oil imports, PEVs are also viewed as a potential source of ancillary services to the electric grid. In 2009 the FERC Chairman Jon Wellinghoff commented that someday vehicles might be used, "…not only to move people from home to work and back but also to support and enhance the nation's electric grid."[28]

The vehicle-to-grid (V2G) concept relies on the ability of PEVs (whether hybrids with conventional engines or vehicles powered solely by electricity) to send power back to the grid on demand. It is theorized that future versions of the PEV will be detectable to grid operators as available resources and called upon as necessary to supply ancillary services to the electric grid. Vehicle owners would be paid the market price for providing the services.

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[24] New York Best Program Plan. March 16, 2010. http://www.ny-best.org/sites/default/files/resources/CAIR%20Plan.pdf.
[25] Annual Progress Report – Vehicle Technologies Program. January 2009. http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/2008_energy_storage.pdf.
[26] Energy Storage Systems Projects. Sandia National Laboratories. March 16, 2010. http://www.sandia.gov/ess/About/projects.html.
[27] NYSERDA / DOE Joint Energy Storage Initiative Demonstration Projects. March 16, 2010. http://www.storagemonitoring.com/nyserda-doe/storage-home.shtml.
[28] Sandalow, David B. (2009). Plug-In Electric Vehicles: What Role for Washington? Chapter 4: The CashBack Car. Pg. 65.

NYSERDA manages programs aimed at supporting the development of advanced PEVs. The New York State Plug-in Hybrid Electric Vehicle Technology Initiative provides $10 million funding for the parts and labor necessary to convert New York State's hybrid vehicle fleet to PEVs. Currently, five vehicles have been delivered to NYSERDA for testing. In addition, NYSERDA's Advanced Vehicle Research and Development Program makes available $5 million to support the manufacture and design of advanced vehicle components within New York State.

In June 2009, the NYISO issued a briefing paper, *Alternate Route: Electrifying the Transportation Sector*, providing a preliminary look at the potential impact of PEVs on New York State's electricity system. In conjunction with the ISO/RTO Council (IRC), the NYISO has conducted an analysis of the plug-in electric vehicle market.[29] That effort evaluates the effects of PEVs on the power system and identifies services that PEVs could provide to competitive electricity markets in North America.

While promising, V2G technology still has a long way to go before it will be ready to have an impact as an energy storage resource available to the electric grid. In order for V2G technologies to be efficient and effective, significant numbers of "capable vehicles"[30] will need to be available to serve the needs of electric systems.

Summary

New energy storage resources represent a promising addition to the resource mix available to serve the electricity needs of the Empire State. The growth of renewable resources, open access to the grid, competitive wholesale electricity markets in New York, and various public policy initiatives at the State and Federal level, have attracted the attention of energy storage resource developers.

The NYISO recognizes the value of these alternative technologies and strives to facilitate the integration of all classes of energy storage resources via a governance process that has led to market rule and software enhancements. The NYISO will continue to support the integration of energy storage technologies, in an unbiased way at all levels of the system, including electric vehicles, grid scale storage and distributed energy technologies.

State and Federal government funding for storage technology research continues to enhance the prospect that energy storage resources will occupy a larger share of the resource mix in the coming years. PEVs and V2G technologies represent a potential new distributed energy storage resource that one day might help to supply the grid with Ancillary Services.

[29] ISO/RTO Council. Assessment of Plug-in Electric Vehicle Integration with ISO/RTO Systems. March 2010.

[30] In order to be capable of supplying services to the grid PHEVs will require additional hardware that will allow the vehicle to send signals to, and receive instructions from, grid operators.

Developments with respect to energy storage projects and technologies are occurring regularly. The NYISO will continue to monitor developments attentively, working with developers to explore grid integration and evolve market design to facilitate the growth of a diverse array of energy storage resources in New York State.